Issue 52
October 2023

Utah Valley Amateur Radio Club

The UVARC Shack

Advancing

Exam session in Eagle Mountain, in which Fui Taotua K7FUI advanced to General and Carl Pockrus WE7OMG advanced to Extra.

In this issue of the *UVARC Shack*

Club meetings feature amateurs with balloons, plus our annual elections.

Silent Key for K7VMH. *My Shack* spotlights K7RLN. *Amateurs in Action* in Washington state. *Brass Tacks* on antennas.

Dear Annette on "no-code" hams and modifying a GMRS radio for amateur use. *Hot Tips* for backup power. *DIY* for a random-wire antenna. *The Amateur in You* on repeater terms and why a tuned HF antenna needs a tuner.

Please send your ideas, stories, questions, gripes, and photos to ***uvarcshack@gmail.com***

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Club meetings

Recap

August 2023 club meeting – Amateur Hot Air Balloon

Kevin Reeve N7RXE taught us about how he coached the high school club he mentors into launching hot air balloons with a camera and an amateur radio (APRS) beacon aboard. Even though he was the coach and mentor, the students did much of the brainstorming, engineering, building, and launching of the balloon. Kevin showed us some of the videos and still shots they made of the balloon's journey into the atmosphere. As a club, we were both mesmerized and engaged by his presentation, and wanted to know more. You can see the presentation here and you can see the YouTube video here.

September 2023 club meeting – Elections and RF Conductors

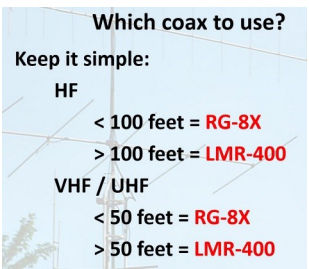
It's election time again, and the five presidency members were up for re-election, but this time there was a challenger, Brent Gray KE7SAO. He challenged Chad Buttars for the Vice President seat, and received a respectable number of votes. But even after the campaign speeches, all the incumbents were retained in their offices, as follows:

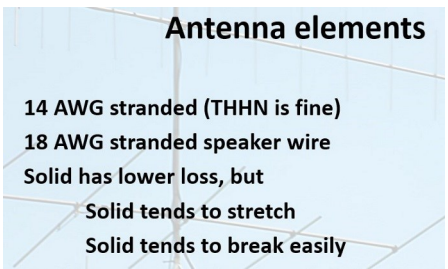
President : Noji Ratzlaff KNØJI Vice President : Chad Buttars WE7CB

Secretary : Caryn Alarcon KG7UUR Activities Specialist : Michele Costello KI7HBP

Technology Specialist : Trevor Holyoak AG7GX

Congrats to all the election winners! We look forward to another fun year of ham radio. Thanks to Alma Perry W1ZGY for running the election and organizing the voting app.




Antenna elements
14 AWG stranded (THHN is fine)
18 AWG stranded speaker wire
Solid has lower loss, but
Solid tends to stretch
Solid tends to break easily

Following the elections, Noji filled the remaining time by giving a brief presentation on ***RF conductors***, such as coax, ladder line, antenna wire, and other antenna elements. He explained velocity factor, compared coax types, and why he recommends specific coax types for typical ham radio stations. You can see a copy of his slide show here and the video of the entire meeting here.

By the way, many of our past meetings are recorded and posted on the club YouTube channel.

Silent Key

Memorial for a ham who has passed on

Von Hutchings K7VMH

On 23 September 2023 Von Hutchings K7VMH left this existence to be with his sweetheart Lila, who preceded him a little over seven years ago. Von was an active 76er since the start of the group, and was a faithful check-in for several years. He attended the Lunch Bunch, ice cream socials and the barbecues as often as his health and his schedule would allow.

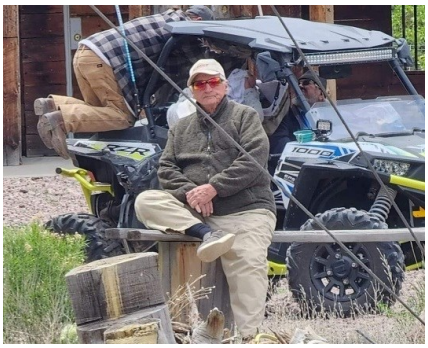
If there's one thing Von enjoyed, it was road trips on his motorcycle, cruising around the country in search of new adventures. He also enjoyed HF, but fell out of commission for a couple of years after his antenna blew down from a windstorm, until Chad Buttars WE7CB volunteered to get on Von's roof and put it back up.

Von got his start in radio by CB, going by the handle *Barefoot Bandit*, constantly communicating with truckers and family while camping. In October 2011 Von discovered the 76ers and got licensed as KF7SGE. A couple of months later, he became KF7VMH. The following July, Von upgraded to General, and a little later he applied for and got K7VMH.

Here are some excerpts from Von's obituary:

Dad taught us to love hard, live full, and be adventurous. He was very active in the LDS Church, volunteered time at the temple, and completed a family history mission. He was active in the Good Sams / Trailblazers Club and the 76ers. He rode his motorcycle and ATV as often as possible, and enjoyed going on rides with family members. To him, there was nothing more important than family.

You will be missed, Von! 73



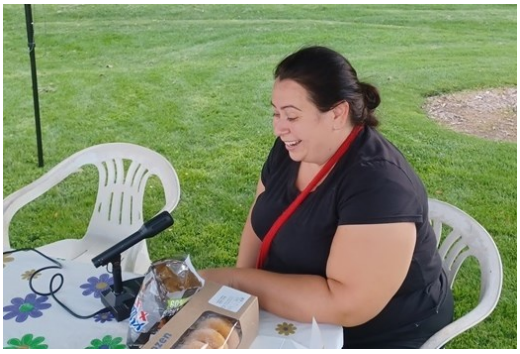
Day in the Park

In photos

Carl WE7OMG and Matthew KL7KUY came up with this great idea to hold a random ham radio GOTA event, to attract locals, and all while Carl was studying for his **EXTRA**

Day in the Park

In photos



Hindley Park, American Fork, Utah 08-23-2023

My Shack

Highlighting the shack (ham equipment and room) of a member, to give others an idea of the possibilities that might work for them

Ralph Nunn K7RLN

I've had a fascination with radio communications ever since I was a child. My father bought me a pair of 'Archer Space Patrol' walkie-talkies for Christmas one year; I must have been about 10 years old. My friends and I would go out into the neighborhood, and play spies. We did that for HOURS - it was a lot of fun. There were days when I would turn it on, and hear other people talking, who sounded like they were truckers. I later came to find out that the walkie-talkie that I owned was crystal-controlled to CB channel 14. The more I learned about CB radio, the more I was fascinated. Of course, this was back in the late 70s, when CB radio was popularized by movies like 'Smokey and the Bandit'.

Then, I had someone tell me once that hey, if you like CB radio, you should check out 'Amateur Radio'. You can talk with a lot more power, and even talk all over the world! Well, that intrigued me even more, but I got on with life, and just kinda filed that away as 'something for another day'.

Well, that day came in October of 2016. I decided to break down, and study for the test, so I passed and become a ham. Why? Because I wanted to figure out how to talk around the world. I'm not sure how I found it, but I got the number of Carl Pockrus WE7OMG, and contacted him about getting a J-pole. I promptly purchased one, put it up out in the yard next to the fence, and put my newly purchased mobile rig on the air; programmed all the local repeaters in, and had a great time.

I later purchased an old 10-meter rig from a gentleman in Taylorsville, along with some coax, a dipole antenna, and a power supply. It was winter time, so I attempted to put the antenna up in the garage. I managed to get it all connected. I turned it on, and called CQ, but there was nothing. I asked Noji KNØJI why I wasn't hearing anything, and he patiently taught me about the solar cycle, and the fact that we were at the bottom of it, and there wasn't much to hear. Dejected, but not deterred, I realized at that point that my Technician class license wasn't going to get me where I wanted to go.

So, I studied for, and passed the General Class license. My next HF rig was a used Yaesu FT-100. I bought all of the parts, and built my first 40-meter dipole antenna, hoisted it up in the backyard, and I was on the air, talking to people all over the country, and having a great time. But, something was still missing...I wasn't hearing DX stations. I saved up for and purchased my current HF rig, the Yaesu FTdx-1200. What a difference good filtering can make!

My Shack
continued

Then, I was at my second year Field Day, and saw something else that was going to change my world. I watched as Ted Cowan NA7C got on the air, and worked other stations - with CW! I was absolutely blown away at how cool that was! Before then, I really had no predilection for the code; I just wanted to talk all over the world. It was then that I made up my mind, and got serious about learning it. Ted encouraged me to 'bury' my microphone as a 'weapon of war'. I took that to heart, and put away my microphone, and solely concentrated on learning the code, by practicing each day. I have come a long way since then. I eventually got to the point that CW is my preferred method of communicating on HF.

So, how about my goal of being able to talk around the world? Well, in November 2020, I tuned into the CQ DX CW contest, to see who I could hear out there. After working a bunch of stations from mostly US, Canada, and South America, I decided to change things up, and switch over to 10 meters. In tuning around for a bit, I happen to hear someone who was 'way down in the noise', but was still able to copy. After listening for a bit, I eventually copied the call sign - VK4KM. HOLY COW - THAT'S AUSTRAILIA!!! But, he was really faint, I wasn't sure that he would hear me. So, I rolled the dice, and took a chance. I sent my call sign out there (K7RLN), and hoped for the best. Lo, and behold, he sent a question mark back to me - meaning that he wanted me to repeat it. So, I sent my call sign two more times. To my utter astonishment, HE SENT IT BACK TO ME! I WAS ABLE TO TALK TO SOMEONE IN AUSTRAILIA - ON THE OTHER SIDE OF THE WORLD! I have fulfilled my life-long dream of being able to talk around the world. Definitely, a high point in my ham radio career.

Amateur radio has given so much to me, so I'd like to give back. I'm happy to help anyone along the way if I can. Just let me know.

- 73, Ralph

Ralph is our perennial CW rock star of Field Day, and his skills are one of the major reasons UVARC does so well.

Amateurs in Action

Recounts of ham radio operators who have used their effort and skills to help others in a time of need

Olympic peninsula emergency averted

Andrew Hoschar K7OWN

Monday 23 May 2022 was a terrific day for Andrew Hoschar K7OWN and a friend to test their new boats out on Wentworth Lake, about thirty or so miles out of their town, Forks, Washington. As they arrived, Andrew's Suzuki Sidekick started making a horrible racket. Checking around, he discovered that the SUV was dangerously low on oil, not even a drop showing on the dipstick.

Andrew knew that if he attempted to return to town, his engine would seize, stranding them in the middle of nowhere. And with absolutely no cell service there, they were stuck. That is, until he remembered that he had brought his HT (handheld transceiver) with him. Andrew called out on a nearby repeater for help.

John Richmond KE7FFX was the first to answer, and Andrew asked John to relay a message to a Heather Lewis, who was taking care of Andrew's son Jacob, and to have Jacob get on the radio. She didn't pick up, so John left a message. After a while, Joe Wright KG7JWW got on and said he was able to get hold of Heather. Eventually, Andrew's son Jacob got on the radio, and Joe answered, *KY7HAM, this is KG7JWW. I believe your dad needs assistance, and requested you contact him on the radio.*

Jacob and Dad were now connected. Andrew told Jacob where the oil was in the shop, and asked him to get hold of his mother, to get hold of neighbor Ted Rasmussen, to deliver the oil to the stranded duo. After a few minutes, Andrew heard the best words he's ever heard in his life, *K7OWN, this is KY7HAM. We have the oil, and we're on our way.* Ted and Jacob drove out to the lake and saved the day.

Jacob Hoschar KY7HAM

While they were waiting, Andrew and his friend proceeded to do what they had originally set out to do: launch and test their boats. His friend was both amazed and a little concerned that Andrew was as calm as he was throughout the ordeal, enough to enjoy the paddle around the lake. *My friend was so impressed by this, that he told me he's going to start studying for his ham license. It's reasons like this, that I'm glad my son and I have these licenses and equipment.*

You can read more about Andrew's near-mishap on *Forks Forum*.

New Hams and Upgrades

New hams

KK7OEE = Robert Hales
KK7OEF = Allan Vance
KK7OEH = Joshua Duglin
KK7OEO = Devon Katz
KK7OFA = Aaron Tracy
KK7OGD = Neven Domenici
KK7OGQ = Brian Eastwood
KK7OHJ = Ryan Marsh
KK7OHV = Zachary Wells
KK7OIC = Matthew Pulsipher
KK7OII = Jeff Stratford
KK7OIL = Trent Holmes
KK7OJF = Konrad Taotua
KK7OJP = Sarah VonClegg
KK7ONB = John Van Dorn
KK7OOS = Duane Butler
KK7OOT = Dale Cox
KK7OPC = Brian Nish
KK7OPH = Rhoda Cox

Upgraded hams

AI7SX = Trevor Bruford (Extra)
KY1X = Troy Dicou (Extra)
K7FUI = Fui Taotua (General)
WE7OMG = Carl Pockrus (Extra)
KK7KOT = Rob James (Extra)
KK7NFL = Porter Clark (General)
KD7MCL = Bradley White (General)

Congratulations to all these diligent folks! We look forward to hearing you on the radio soon.

Events

Upcoming happenings

DIY Night

Our November 2023 club meeting will be our annual DIY (do-it-yourself) night, where you can learn (or help teach!) a skill or concept to club members. This one will be held Thursday 02 November at the Orem City Council Chamber Room, 56 N State St, starting 6:30 pm. Come learn about soldering, installing a connector, using Anderson Powerpoles, how to apply heat shrink, how to program a radio, how to set up your own mini-repeater, how to analyze an antenna, and more. More as we get closer.

If you'd like to showcase a concept, please let one of the club leadership know. We'll give you a half-table to set up your demo and poster board or literature!

2023 Annual Christmas Potluck

Set aside the night of Thursday 07 December from 6:00 pm, for the biggest potluck of the year, at the Orem Senior Friendship Center, 93 N 400 E. We'll announce a sign-up sheet later. Santa said he's planning to be there to sample our goodies, so bring your little ones, to get photographed with Jolly ol' St. Nick himself. Seconds for those who get their photo taken on his lap. We'll also have tables set up in back for you to show off your latest projects. More details to come.

76ers Santa Net

The 76ers Santa Net tradition continues! The revered and long-anticipated net will take place on Saturday December 23 and Sunday December 24, at 6:00 pm on the 146.760 MHz repeater. Open to anybody, young or small, who wants to talk with Santa, but there must be at least one person at your station who is licensed. To participate, simply bring your little ones to the radio, have them announce your call sign into the microphone when Santa asks for them, and when Santa calls for them, they can talk away at will. When they're done, they can say Thanks, give your call sign, and turn it back to Santa. No need for you to say anything, or intervene in any way, unless they're too young to do or say some of that.

Winter Field Day 2024

The Utah Valley Amateur Radio Club is planning to participate in Winter Field Day 2024 at the Lindon Marina, and all are invited. We'll be setting up our station as early as Friday January 26, but we'll actually be on the air, calling *CQ Field Day!* from noon Saturday January 27 through noon Sunday.

We'll need help setting up antennas, radios, and other parts of our three stations starting early Saturday morning. Afterwards, we'll need help taking it all down Sunday, right at noon too. Please bring gloves. The club will provide dinner in the form of pizza and soft drinks between 5 pm and 6 pm Saturday January 27 inside or next to one of the trailers. All hams and their families are welcome to join the fun! This might be your opportunity to get on the air and make your first HF contact, even if you have no license. This is the link to the location. And this is the link to our Winter Field Day information page.

Events

Upcoming happenings

Brass Tacks

An in-depth look at a radio-related topic

The antenna

Among all the items making up a complete amateur radio station, the *antenna* is arguably the simplest component with the most complex and perhaps the most important job. To many of us, it's a passive device that converts electrical signals into radio waves, and converts radio waves into electrical signals. This is a discussion about the fundamentals, the rudiments, of how an antenna works, without requiring a college degree.

While proving the existence of radio waves, as predicted by James Clerk Maxwell, Heinrich Hertz invented the antenna in 1888, although that's not what he called it. In the summer of 1895, Guglielmo Marconi was experimenting with electrical conductors suspended from masts, raised to help increase the reach of his transmitted signals. He made mention of the fact that some of his wires were held up by a tall tent pole, which in Italian is *l'antenna centrale*, the word l'antenna having had its origins with ship masts. Soon, the shortened *antenna* spread among researchers, then experimenters, then the world in general.

The term *aerial*, used in the UK for antenna, simply means *of the air*. People have sometimes used *antennae* as an outdated plural for antenna, but today that word refers primarily to the pair of appendages that protrude from the head of an insect.

The physics

Let's start with the basic laws of nature by which an antenna performs its magic, then expand on the various characteristics that identify its properties. Still, a rudimentary (not elementary) discussion cannot take place without mentioning *some* physics, because that's where it all begins. And to help make the explanation a little easier to grasp, let's assume that we're using a perfectly resonant and lossless antenna, whose feed point impedance exactly matches the feed line characteristic impedance.

The entire story behind the physics of an antenna begins with *electric charge*, a fundamental property of matter, in which a particle that possesses this influence exhibits electrostatic attraction or repulsion in the presence of another particle possessing the same property. Next is *Coulomb's Law*, which states that the force between two charges (q and q_0) is defined as

$$F = \frac{1}{4\pi\epsilon_o}\frac{qq_o}{r^2}, \text{ but since } E = \frac{F}{q_o} \text{ (definition of the electric field), } E = \frac{1}{4\pi\epsilon_o}\frac{q}{r^2}$$

introducing the concept of an *electric field*, which emanates from each charged particle.

For a moment, let's examine how a *capacitor* works, since an antenna is fundamentally a type of capacitor, and functions like one in some respects. A capacitor has two conductors that are

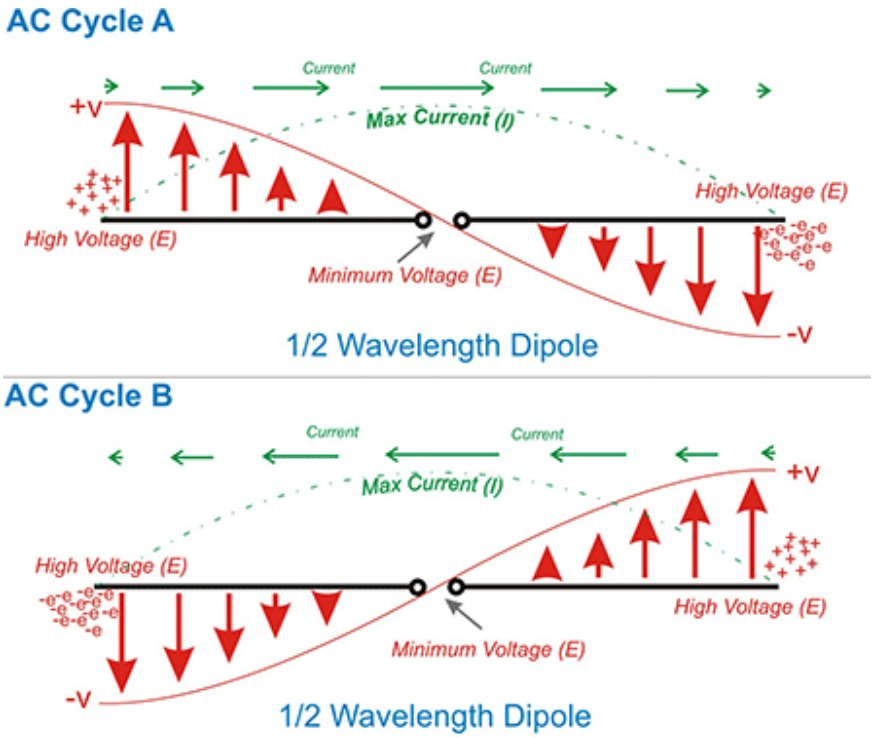
Brass Tacks

continued

separated by an insulator. At an initially discharged state, the two conductors have equal amounts of opposing charges on both conductors, so the resulting net electric field between the two is zero. These charges are electrons that exist in the conduction band of each metallic atom, and are spread uniformly throughout each conductor.

When a voltage potential (battery, for example) is presented across the two conductors of a capacitor, the electric field within the conductors become nonzero, resulting in the momentary migration (flow) of the electrons in the conduction band from one atom to the next, further resulting in a net accumulation of electrons (negatively charged) in one conductor and depletion of electrons (positively charged) in the other.

Like the capacitor, this accumulated separation of negatively and positively charged ***elements*** (radiating sides, also called *radiators*) of a ***dipole antenna*** results in a nonzero electric field between the two conductors, which of itself is not all that interesting or useful. But, suddenly switch the polarity of the voltage potential, and the electrons now rush to the other end. This reversal of charge migration will reverse the electric field (same field type, but with opposite polarity), because the voltage potential controls that charge accumulation. Reverse the voltage polarity again, and the process re-repeats in the reverse direction, and so on.



The electric field is an influence that is emitted from the charges at the speed of light, and the alignment of the electric field is what we refer to as the signal ***polarization***. The continual reversal of charge polarity therefore results in the continual reversal of (change in) emitted electric field polarity. We say that antenna orientation (physical alignment) determines signal polar-

Brass Tacks

continued

ization (electromagnetic field alignment).

According to Ampere-Maxwell's Law, a changing electric field produces a magnetic field that changes at the same time (same frequency and phase). This combination of the changing electric field and changing magnetic field is what we call *electromagnetic radiation*, or ***radio waves***, and it moves out (*propagates*) from the antenna at the speed of light.

Because the electromagnetic radiation produced by an antenna is a composite (observed together) of its continually changing electric and magnetic fields, let's consider them as though they were a single field, which I'll call the *electromagnetic field*. When this electromagnetic radiation (radio wave) strikes a metal object, such as a receiving antenna, its oscillating electromagnetic field causes the electrons in the antenna to accumulate at one side of the dipole antenna and then the other, according to Faraday's Law of Induction.

The electrons begin moving back and forth along the conductor with the same frequency as that of the radio wave. This resulting *alternating current* is then brought into the radio for possible processing to reproduce an intelligent sound, assuming an intelligent signal was received. Whew...we got past the hard part!

The dipole antenna

An ideal antenna that can transmit equally in all possible directions is known as an ***isotropic*** ("equal turn" or "exhibits the same properties any way you turn it") antenna or radiator, and cannot be realized (made), but is used as a reference tool for textbook and theoretical antenna property discussions. Comparisons with an actual, nearly ideal antenna require the ***dipole antenna*** to as the reference, because of its simple design and well-known characteristics.

A dipole antenna is a pair of equal-length (and ideally colinear) conductors, each of which is connected to one of the conductors in a feed line, such as coax. In one form or another, nearly every antenna is, or has at its heart, a type of dipole, in that radio waves are emitted from one side of the dipole and received on the other, then the operation is reversed a half-cycle later. The two sides are connected by capacitance, with air or space as the separating dielectric.

An antenna that's built using only one of these two halves (known as a monopole) still requires the missing counterpart, or ***counterpoise***, for proper operation. In this case, an antenna will often make use of other conductors that can return the signal to the radio, such as the chassis of an HT (handheld transceiver) or the shield of the coax (coaxial cable), if one's attached.

Brass Tacks

continued

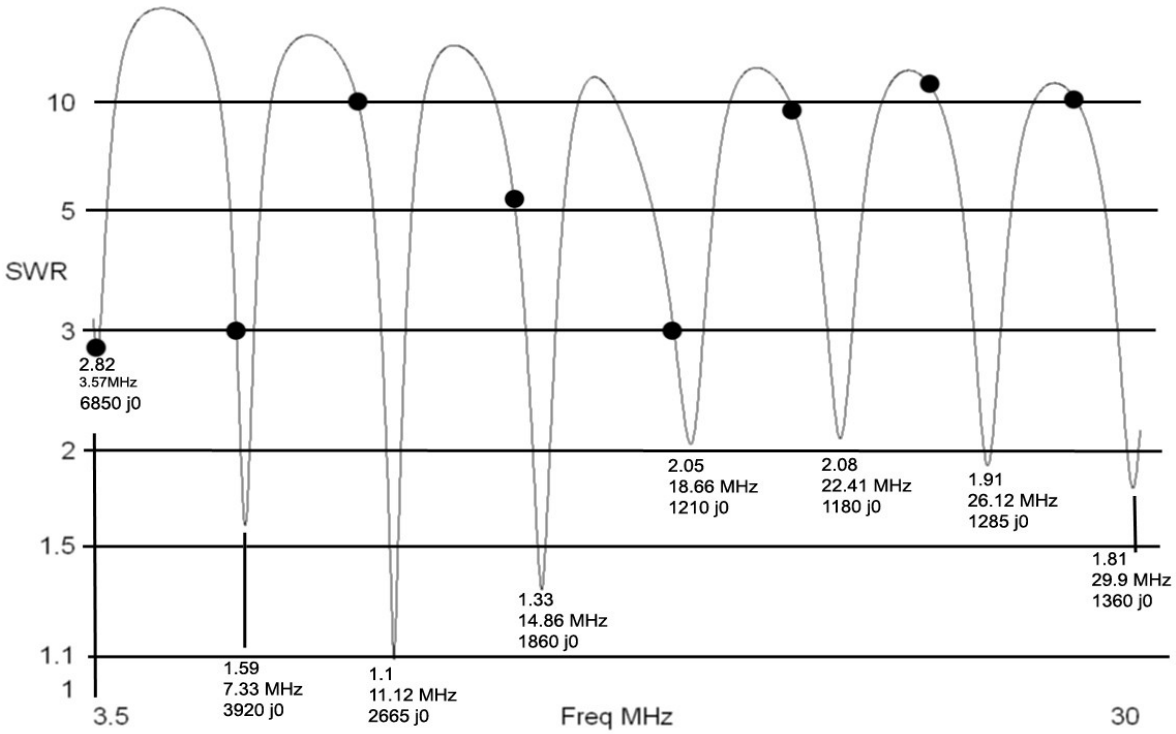
Antenna resonance

But isn't the antenna being bombarded by radio waves of a jillion different frequencies at any given moment? Yes, it is, so which frequency of radio wave gets "picked up" best by the antenna? In the case of the dipole antenna, it's the frequency that will result in the greatest difference in voltage between the feed point of the dipole and that of the end of the element.

During any frequency cycle, the moving charges accumulate at one end of the antenna, then the other. If the conductor is precisely the size (due to geometry and medium, which controls the velocity factor) at which the accumulated charges reach a maximum accumulation at one end and a minimum accumulation at the middle (feed point) of the dipole at the same time, the voltage displacement (potential difference) is at maximum, resulting in maximum current flow at that frequency.

This is known as ***antenna resonance***, and the frequency of maximum current flow is called the ***resonant antenna frequency***. A signal whose frequency that does not produce this maximum displacement will cancel some of the effect, resulting in non-maximum current flow. Resonance means that the antenna feed point impedance is ***real***, since any portion of the signal power that is ***imaginary*** is not radiated, but is reflected back, and so contributes to SWR.

It's important to note that signals of frequencies near but not exactly the same as the resonant frequency will also be received. But their induced current strengths will be attenuated



Display of "long wire" antenna resonance points

Brass Tacks

continued

(reduced) compared with what might otherwise have been realized at the resonant frequency. On the other hand, if you extend the antenna element far enough to where another half-wave of the signal is producing another maximum displacement, you can see that an element that's 3/4 wavelength is also resonant. In fact, every odd-quarter-wavelength multiple of the element size is also resonant, since the impedance at those points are also real.

Antenna size

The actual size of the dipole that is resonant for the signal of a required frequency can be calculated by considering that one half-cycle of the signal will result in a maximum voltage difference (from the smallest to the largest positive) on one element of the dipole, and the reverse maximum difference (from the smallest to the largest negative) on the other. This translates into the highest to the lowest peak of the radio wave, which amounts to a *half-wavelength*.

Calculating the half-wave dipole size requires knowing the VF (***velocity factor***) of the material being used for the wire. The VF is the speed of electrical energy in the material, and is expressed as a fraction of the speed of light in a vacuum. For example, the VF of copper at room temperature is 0.95, meaning that electrical energy can travel 0.95 × 300 Mm/s ≈ 285 Mm/s in bare copper.

Let's say we want to design a half-wave dipole antenna for 20 meters, at about 14.175 MHz, using bare copper wire. The entire length of the dipole should be a half-wavelength, making it 300 Mm/s ÷ 14.175 MHz = 21.164 m for one wavelength (symbol **λ**), and 21.164 m ÷ 2 = 10.58 m for a half-wavelength. But that's how far one half-wave travels (per 1/14.175 MHz/2 seconds) in a vacuum, yet the electrical energy in the bare copper wire travels a bit slower. In fact, it travels 0.95 times the distance, or 10.58 m × 0.95 = 10.05 m in the same amount of time. Converting meters to feet gives us

$$10.05\ \text{m} \times 39.37\ \text{in/m} \div 1\ \text{ft}/12\ \text{in} = 33.0\ \text{ft}$$

A convenient "tool" for us Americans, to calculate dipole lengths is the number ***468***, which is nothing more than a conversion factor that a) converts MHz to feet and b) includes the 0.95 VF by assuming the half-wave dipole elements are made of copper. This way,

$$468 \div 14.175\ \text{MHz} = 33.0\ \text{ft}$$

The value "468" is derived from converting from MHz into feet, then multiplying by the VF of copper

$$\left(\frac{1}{2}\lambda\right)\left(\frac{300\ \text{Mm/s}}{14.175\ \text{MHz}}\right)\left(\frac{39.37\ \text{in}}{\text{m}}\right)\left(\frac{1\ \text{ft}}{12\ \text{in}}\right) \times 0.95 \approx 468$$

then, further divide that by 2 for the length of each (dipole element) side.

One more antenna property you might want to be aware of is known as ***aperture***. This is the amount of conductive surface an antenna can present or expose to an electromagnetic field. Typically related more to receiving antennas than transmitting ones, essentially, the more of your antenna you can expose to the field, the more signal it can collect. Many microwave, tele-

Brass Tacks

continued

vision, and other antennas use parabolic dishes to maximize their aperture, to collect the most signal at the frequency in question.

To make an effective shortwave radio antenna, for example, simply purchase a 500-foot roll of wire from your favorite hardware store, and string the wire all over your trees, bushes, and even over your house. You might be amazed how well your radio can receive signals with this wire, even if the wire isn't cut precisely for a particular resonant frequency.

Antenna efficiency

An antenna property that's often misunderstood is ***efficiency***. The classic definition informs us that the efficiency of an antenna is the ratio between the amount of power radiated from an antenna to the power that's absorbed by the antenna. On the surface, this sounds clear and simple, but once we examine the details of that power, its story is no longer so innocent-sounding.

For example, let's say we send 100 watts PEP from our transceiver to the antenna, and ignore transmission line losses for now. Due to a mismatch, say 3.0:1 SWR, 25%, or 25 watts will be reflected back from the antenna to the transceiver. We can conclude that 75 watts was absorbed by the antenna, and we'd be correct. But what did the antenna do with that 75 watts of power?

Part of the power is radiated out into space, but part of it ("ohmic" power) is emitted as heat. The applicable equation for power is $P = I^2R$, and because this circuit possesses two power-consuming entities, $P_T = P_{rad} + P_o$ (power absorbed equals radiated power plus ohmic power), and so $P_T = I^2R_{rad} + I^2R_o$ (current times radiation resistance and ohmic resistance). Therefore, $R_T = R_{rad} + R_o$ (total resistance equals radiation resistance plus ohmic resistance).

Returning to the definition of antenna efficiency, therefore, the efficiency of the antenna is the ratio of the power radiated to the power absorbed, or $\eta = P_{rad}/P_T = P_{rad}/(P_{rad} + P_o)$. Canceling the currents, we have

$$\eta = R_{rad}/(R_{rad} + R_o)$$

or the efficiency η is equal to the radiation resistance divided by the total (radiation plus ohmic) resistance.

Therefore, antenna efficiency has nothing to do with SWR, reflections, feed line losses, or how well matched an antenna is. Furthermore, by reciprocity, the efficiency of a receiving antenna is identical to its efficiency as a transmitting antenna.

Antenna gain

Antenna ***gain*** is one of the most misunderstood and misused properties of an antenna, yet is used to compare one antenna with another, often without regard to more important attributes, such as radiation pattern or feed point impedance. Antenna gain is the ***direction of its strongest signal***, whether that signal is transmitted or received. The degree to which the antenna signal vectors are concentrated in one direction more than in others is called its ***directivity***.

Gain, therefore, is a measure of antenna directivity and is equal to $G = \eta D$, in which η is the

Brass Tacks

continued

antenna efficiency and D is its directivity. The quantity of signal strength in a particular direction is known as *power density*, and is measured in W/m², or watts per square meter. Power density is calculated as

$$P_D = \frac{P_{rad} G}{4\pi d^2}$$

in which P_D is the power density, P_{rad} is the antenna output radiated power, G is the antenna gain, and d is the distance between the antenna and the measurement point.

The gain direction is usually accompanied by a value that compares the antenna's maximum potential strength with that of a reference antenna, which is traditionally either an isotropic radiator or a half-wave dipole. Antenna gain listed in **dBi** indicates that it's being compared with that of an isotropic radiator. Gain listed in **dBd** indicates a comparison with that of a half-wave dipole.

Antenna gains listed simply as **dB** have an indeterminate meaning, so we must assume the worst case, which is dBi. Some advertisers will list a gain in dB in an effort to mislead the unsuspecting buyer into a more attractive purchase. To convert a dBi value to a dBd value, simply subtract 2.15 (free space), so that an antenna listed as 9 dBi or even 9 dB is actually 9 dBi – 2.15 = 6.85 dBd in free space.

The dBd value is useful in calculating the **ERP** (***effective radiated power***) output of a station, since ERP is relative to a half-wave dipole. For example, say your radio is set to transmit on 20 meters at 100 watts maximum, your antenna gain is listed at 9 dBd, and you're using 50 feet of RG-58 coax. What is the resulting ERP from your antenna? The calculation is basically

ERP = PEP + gains – losses

The 'PEP' value is the amount of power that your rig is transmitting. Next, your transmission line is RG-58 coax. Looking at the coax chart, you can see that for 20 meters RG-58 exhibits 1.7 dB loss per 100 feet. This means for 50 feet, or half that length, your coax loss is 1.7 dB loss ÷ 2 = 0.85 dB loss at 20 meters. So, your total ERP is now

$$\begin{aligned} \text{ERP} &= 100 \text{ watts} + 9 \text{ dBd} - 0.85 \text{ dB} \\ &= 100 \text{ watts} + 8.15 \text{ dBd} \\ &= 100 \text{ watts} \times 10^{(8.15/10)} \\ &= 100 \text{ watts} \times 6.53 = 653 \text{ watts} \end{aligned}$$

Which means your station is putting out 653 watts of power! Wait a minute...how can you get more power out of your station than you've put into it? Is your station somehow violating the laws of physics, or maybe generating extra power? Remember that antenna gain is the direction at which the maximum signal power is directed. In other words, just like with a flashlight, the reflector dish doesn't magically generate more light, it only focuses the light that it does have, more in one direction than in others. So, ***it appears*** that your station is putting out 653 watts in a particular direction (actually W/m²), and that appearance is ERP.

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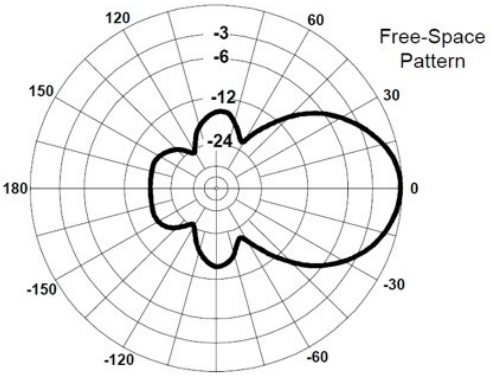
The dBi value can also be useful for when the *EIRP* (effective isotropic radiated power) is requested. The newest amateur bands, the 630-meter band and 2200-meter band, for example, list the maximum allowable output in EIRP. To calculate that value, first convert your antenna gain into dBi, and repeat the steps.

A physical principle known as *reciprocity* states that the receiving characteristics (gain, radiation pattern, bandwidth, resonant frequency, efficiency, etc.) of an antenna are identical to its transmitting characteristics. This means that if an antenna exhibits gain in a particular direction, both its receiving and transmitting ability are strongest in that same direction.

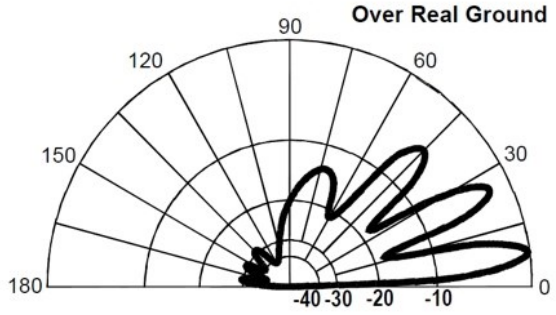
Antenna radiation patterns

If we were to shrink the antenna down to a dot, and examine the radio waves emanating from it, we call that examination the ***far field***. This kind of approach allows us to determine antenna and field properties independent of close-range anomalies that are not relevant to the discussion. Next, let's draw a line from that dot in any direction, such that the length of that line is proportional to the transmitted signal strength in that direction, without regard to where on the antenna the signal originated. Let's then draw another line from the dot in any other direction, and with the same requirement.

Once we draw enough of these lines, we begin to see the formation of a three-dimensional shape, which displays what we call the ***antenna radiation pattern***. This visual model gives us an idea of not only the gain direction, but the relative peaks (high points) of the transmitted signals in other directions as well. The resulting balloon-like figures are called ***lobes***, with special attention drawn to the front (front lobe), back (back lobe), and sides (side lobes), especially if the antenna exhibits significant directivity.



Azimuthal view of a Yagi pattern



Elevation view of a Yagi pattern

Although antenna gain is defined as the direction of maximum radiated strength, it doesn't tell the whole story. An antenna might also exhibit a strong signal in a slightly different direction, and maybe another, and another, which is very common among actual antennas. The pattern lobe of the gain is called the ***main lobe***, and all other lobes are measured relative to the main lobe.

Because of our reliance on two-dimensional displays, we typically draw antenna pattens from either a side (*elevation*) view or top (*azimuthal*) view. There are certainly three-dimensional drawings that display a more complete model at once, but a two-dimensional picture tends to be easier to draw. The side, or elevation view can display wasted radiated power and the antenna's takeoff angle, which we'll discuss shortly.

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continued

The top, or azimuthal view helps us understand the lateral (compass N-S-E-W) directions of the lobes, the nulls, and the antenna beamwidth. Combined, they can easily display antenna directivity.

Beamwidth

Examining the azimuthal pattern, if the antenna exhibits some directivity, we surround the pattern with a circle, using the antenna dot as the center of the far-field and the main lobe as the radius. We then label that outer circle "Ø dB" because it's our reference, since all other points are relative to the main lobe. We then draw a second circle 3 dB (half the maximum main lobe signal power) closer to the center, and mark where the major lobe crosses the –3 dB circle. The angle created by those two intersections is known as the ***half-power beamwidth***. This graphically displays how much *effective* sweep angle an antenna covers.

From the azimuthal pattern on the previous page, you can see that the antenna beamwidth is the difference between the positive angle where the main lobe intersects the –3 dB circle and the negative angle where they intersect again. It appears that the two angles are approximately +25° and –25°, and the difference is the beamwidth, or BW = (+25°) – (–25°) ≈ 50°.

Takeoff angle

Examining the elevation pattern, let's again focus on the gain, the direction at which the strongest signal radiates. The main lobe angle over flat ground is known as its ***takeoff angle***, because it looks as though the signal is "taking off" from the antenna dot into space. Understanding the takeoff angle of an antenna can be important if you're trying to target a distant (DX) land or some place nearby (NVIS).

If your antenna's takeoff angle is very low, say, 10 degrees, it's set to strike the ionosphere very far away, and can reach a distant station with fewer hops (bounces of refractions off the sky and reflections off the Earth) than can one whose takeoff angle is higher. Fewer hops between stations means less signal loss, assuming ionospheric conditions are favorable. If your antenna's takeoff angle is very high, say, 80 degrees, it's better suited for *NVIS* (near-vertical incidence skywave) contacts within 200 to 500 miles, an area that could otherwise end up in the ***skip zone*** for one with a lower takeoff angle.

From the elevation pattern on the previous page, you can see that the antenna takeoff angle is the angle made by the main lobe over real ground. In this case, it appears to be approximately 8°, which is pretty low for a Yagi antenna, unless it's been mounted fairly high up. Judging by its pattern alone, I'd say that this high-gain antenna can easily be used for making DX and domestic contacts alike.

Takeoff angle can be controlled by antenna type and antenna height. Vertical and other monopole-type antennas tend to exhibit a very low takeoff angle, and are typically better suited for DX. On the other hand, vertical antennas tend to be noisier, because of their lack of signal rejection in any direction. A Yagi beam antenna tends to exhibit a higher takeoff angle, making them more suitable for continental (within our own continent) contacting. But increasing the height of a Yagi can reduce its takeoff angle, and allow for much farther propagation.

Reciprocity

In the world of amateur radio, antennas have two basic arenas of function, transmitting and

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continued

receiving. And because of reciprocity, each antenna's receive pattern is identical to its transmitting pattern, although experience doesn't always make that seem obvious. That pattern determines in what direction the antenna gain is pointed, as well as the directions of its relative signal strengths or sensitivities. And different antenna shapes, sizes (lengths), and especially its height over ground, affect that pattern, for both transmitting and receiving.

Antenna impedance, SWR, and matching

Because an antenna is an electrical component, it exhibits ***impedance***, which is the opposition to current flow through it. To function ideally as an effective signal radiator, an antenna must convert all of the electrical signal sent to it, into radio waves. This can only occur if the antenna is completely lossless and its *feed point impedance* (impedance measured at the point where the feed line connects to the antenna) perfectly matches that of the feed line.

But even in the lossless antenna case, if the feed point impedance does not match that of the feed line, a portion of the signal sent to the antenna will be reflected back to the transceiver. The measure of this relative quantity of signal reflection is called the ***SWR*** (standing wave ratio), and is a function of the difference between antenna (load) impedance Z_L and feed line (characteristic) impedance Z_0, as follows (Γ is known as the *reflection coefficient*):

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \text{ and } SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

Because of the reactive (opposed to the resistive) nature of the transceiver output, the entire signal that was reflected by the mismatched antenna will be re-reflected by the transceiver to the antenna again. Therefore, if the feed line is completely lossless, all of the transceiver signal will eventually be sent out through the antenna, regardless how badly matched they are. The lower the feed line attenuation (loss), therefore, the less of a concern SWR is.

If you're using coax (coaxial cable) as your feed line, then keeping your SWR down can reduce the signal power lost through your coax. To reduce SWR, either construct your antenna geometry to more closely manage the signal of a given frequency, or use an impedance matching device. One such device is an impedance transformer, which you can easily make, but often only covers a limited frequency range. Another is a ***tuner*** (ATU, or antenna tuning unit), which can often cover a much larger range.

Antenna types

This section alone can serve as its own book. We've already covered the dipole antenna, because it's a reference antenna that's very effective, easily constructed, and is the foundation of most other antennas. Without listing every antenna ever made, there are a few important ones that are worth mentioning.

The monopole

An antenna constructed from a single radiating / receiving element is known as a monopole antenna, and is simply half of a dipole antenna, using an Earth connection for the other half. You've no doubt seen examples of this common type of antenna on vehicles, HTs (handheld transceivers), AM broadcast station towers, and portable FM broadcast receivers. Invented in

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continued

1896 by Marconi, the monopole antenna was once called the *Marconi antenna*.

My own monopoles

A monopole antenna emits its signals omnidirectionally from an azimuthal point of view. From an elevation perspective, it radiates its signals primarily outward from (perpendicular to) the antenna, plus a lesser percentage of the signals at a slightly upward angle and some at a slightly downward angle. The downward signals are reflected by the Earth and sent back upward, adding to the upward-angle signals.

At a quarter-wavelength, a monopole antenna is resonant, meaning its feed point impedance is purely resistive. At lengths shorter than a half-wavelength, the monopole impedance will exhibit capacitive reactance, and between a quarter-wavelength and half-wavelength, it'll exhibit inductive reactance.

While it's possible to mount a vertical monopole above ground, like on your roof, it's also possible to mount one right on the ground, often a convenience advantage of monopole antennas over other types. But to maintain the feed point impedance at its optimum, it needs a ***counterpoise***, to compensate for the bottom half of the dipole, especially if it has a poor connection to Earth ground. This counterpoise is often achieved by the use of radials, which are nothing more than wires that are connected to the non-radiating side of the antenna, spread out radially (hence the name) from its base.

The Yagi antenna

The one highly performing antenna sought for by most serious hobbyist and contester hams is the ***Yagi-Uda*** antenna, which we tend to abbreviate as Yagi, pictured at the start of this discussion. The Yagi antenna is known for its high gain and high noise rejection. Similar to narrowing a flashlight beam, to concentrate its light to a smaller area, a Yagi antenna can be made with high directivity, providing more focus of the signal "beam" in a particular direction, and leading us to refer to such a Yagi antenna by the nickname ***beam*** antenna.

And in the receiving case, due to reciprocity, because more focus is placed in the gain direction, the Yagi beam antenna receives signals from other angles much more poorly, allowing for high passive noise reduction from sources other than those in the forward heading. This is possibly the biggest performance difference between a vertical antenna and a beam antenna.

Perhaps the biggest downside to the Yagi beam is the fact that you'll need to rotate the antenna toward your signal to communicate well with a contact in that direction, requiring you to install an *antenna rotator* that you can control from within your shack. Then again, a few amateurs who live away from metropolitan areas do install their Yagi antennas permanently trained in a particular direction, possibly at a favorite repeater or group of repeaters.

Brass Tacks

continued

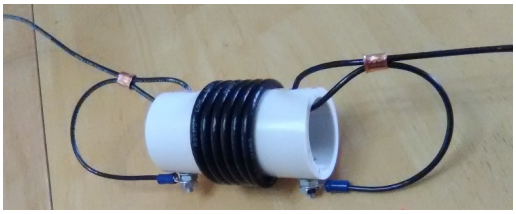
Electrically short antennas

Due to resonance, an antenna ideally possesses a geometry (specific length or other dimensions) that's defined by its operating frequency. Yet, that often leads to excessively long wires or height for antenna elements, making the antenna cumbersome and maybe even a bit dangerous in some circumstances. It's possible to shorten this same antenna, while retaining its effectiveness at the target frequencies, by using a ***loading coil***, either at the base of the antenna, or near the middle of it.

A loading coil allows the antenna to retain its optimal length through all the wire that's coiled up in it. But, the coil often adds serious inductance to the antenna, requiring added capacitance to bring the antenna back to resonance at the frequency of interest. For this reason, a capacitance hat or other methods are often used on a vertical antenna that has been shortened below its quarter-wavelength height.

Trap antennas

One way to create an antenna from a single wire that is resonant on two or more different bands is through an antenna ***trap***. A trap is (typically) a passive device that, through a simple tuning circuit, can allow for signals of one supported band to pass through it, while it filters out ("traps") those of the other band.



20/40 antenna trap

Finally

Antennas seem like such simple, innocent devices. Yet, explaining how they work can get really complicated really fast, so in spite of how long it is, our discussion has scaled down much of the detail to the level of a club newsletter.

If you'd like to pursue the ultimate education on antennas, a degree in RF Engineering would definitely help you achieve your goal. To focus only on antennas, you can study the *de facto* standard antenna reference, *Antenna Theory Analysis and Design*, by Constantine Balanis, the undisputed authority on antennas. But caution: advanced calculus and physics are required, without which, brain damage or partial blindness can easily result. :-)

Another recommended work that's more down to an amateur level is the ***ARRL Antenna Book***, which can be purchased from Amazon or from ARRL directly. The *ARRL Antenna Book* not only covers basic antenna theory, but also discusses performance and design characteristics.

Summary

An antenna is a non-trivial device that converts electrical signals into radio waves, and/or collects radio waves and converts them into electrical signals. Properties such as impedance, geometry (size and aperture), gain, radiation pattern, and resonant frequency, must be taken into account for effective antenna use. There are several categories of antennas, yet nearly every antenna can be thought of as a dipole in one respect or another. Efficiency, gain, and SWR are widely misunderstood antenna properties that might deserve some homework time if you plan to discuss them intelligently.

Noji Ratzlaff, KNØJI (kn0ji@arrl.net)

Dear Annette

What's on your mind? Serious, humorous, technical, and thoughtful answers to your deepest, (mostly) ham-related questions.

Dear Annette:

Why do some long-time ham operators refer to me as a "no-code" ham operator, just because I don't do Morse code? I mean, is that label necessary in some circumstances?

Jody in Orem

Dear Jody:

Adding that unnecessary label seems to help some hams maintain their superiority complex by compartmentalizing their personal feelings of having been seemingly cheated by a system that bestowed upon them a class of operation whose requirements have since been modernized in a way that now somehow offends their sense of fairness.

Dear Annette:

Can I modify a walkie-talkie to legally use on ham frequencies, if I know of a mod for it?

Sam in Riverton

Dear Sam:

You can modify anything you want, to transmit on amateur radio frequencies. Just keep in mind that modifying a radio that has been certificated (formerly "type-accepted") for another service, such as FRS, GMRS, MURS, or CB, typically renders that radio no longer legal for transmitting on that service.

Dear Annette:

I know that I shouldn't put antennas on utility poles that are owned by the city, but what if I put one on a utility pole that I own, that I know isn't powering anything?

Alan in Clearfield

Dear Alan:

Even if the utility pole belongs to you, in my opinion, if it looks like a city-owned utility pole, it's not a good idea to install an amateur radio antenna on it, primarily because of the "appearance of evil." A newer ham who respects you, for example, might want to imitate your setup on a city-owned pole.

Dear Annette:

Can sound travel in a vacuum? If not, then how does my radio send my voice through the vacuum of space?

Dent in Pleasant Grove

Dear Dent:

Great question! Sound is the vibration of molecules, and there aren't a lot of molecules in space to carry sound. Radio waves are also incapable of carrying sound, but they can be shaped like a sound wave, which a receiver can use to re-create the original sound. It's kind of like passing a clay impression of a key to your friend in prison, who then re-creates the key using your clay impression.

Dear Annette:

Is it legal to use a Morse code encoder and decoder to talk CW with others on the radio?

Ron in Orem

Dear Ron:

As a licensed amateur, you are free to use an automatic or electronic Morse code encoder and/or decoder to communicate CW on the air. In fact, there are a good number of hearing-impaired amateurs who have wanted to listen in and join the conversations, but could not, and this allows them to enjoy the craft in spite of what life has handed them.

Got a question for Dear Annette*? Email it to* ***uvarcshack@gmail.com*** *and include your town name. Sorry, no guarantees.*

The Amateur in You, Part 1

What have you been pondering?

Repeater operation terms and phrases

Many of us are acquainted with using a repeater, and are familiar with terms associated with repeater operation by amateurs. But, not everybody who's licensed knows them well, and there are some slang and other phrases that are good to know. Here's a quick review of some of the more common ones you might encounter:

- A repeater has an ***input frequency*** and an ***output frequency***. What you hear from the repeater is from its output frequency, and when you press the PTT, you're sending to its input frequency. The difference between these two frequencies is called the ***repeater offset***.
- To ***open a repeater*** means the repeater is able to hear you well enough to perform its repeat function. Typically, a repeater also requires a ***repeater tone*** to open the repeater.
- If a person is not able to ***hit the repeater***, it means he is unable to open the repeater. So, ***hitting the repeater*** means the repeater can hear and acknowledge your transmission.
- If you're not ***in the repeater***, it possibly means your radio is not set to the proper offset, or is on simplex to the repeater output frequency.
- When you hear somebody ***on the repeater***, and there's no background noise or hiss in his audio, it means he's ***full quieting into the repeater***.
- After you release your PTT at the end of your transmission into the repeater, you might hear a ***courtesy tone***, which is often a beep, followed by a short, loud staticky sound, known as the ***squelch tail***. Afterwards, you might hear the ***repeater ID***, which is the repeater announcing its call sign, often in Morse code.
- While hearing somebody attempting to talk ***through a repeater***, meaning he's trying to use the repeater, you might hear a syllable here and there, but maybe not a full sentence, because the signal keeps ***cutting in and out***. We tend to say that he's not ***holding the repeater***, meaning that the repeater is only occasionally hearing him.
- Sometimes, you might hear somebody who's ***tying up the repeater***, meaning that he and a friend are talking on it so long that others who might want to use it have little chance to use it for themselves.
- A person can talk on the repeater so long that he might ***time out the repeater***, which causes its ***time-out timer*** to disable the repeat function and ***reset*** or ***reboot the repeater***.
- Excessive timeouts can cause the repeater to ***go down***, until the ***repeater trustee*** can restore it to normal operation.
- Many repeaters are linked together by the internet or other means. We call that a ***repeater system***, and the repeater you use to get onto that system is a ***linked repeater***.
- Finally, there are times when you might want to communicate on the repeater output frequency, which operation is called ***talk-around***, because you're talking around the repeater and not going through it. A similar operation takes place when you talk ***on reverse***, meaning you send on the repeater output and listen on the repeater input, which is useful for listening to somebody who might be having a difficult time hitting the repeater.

The Amateur in You, Part 2

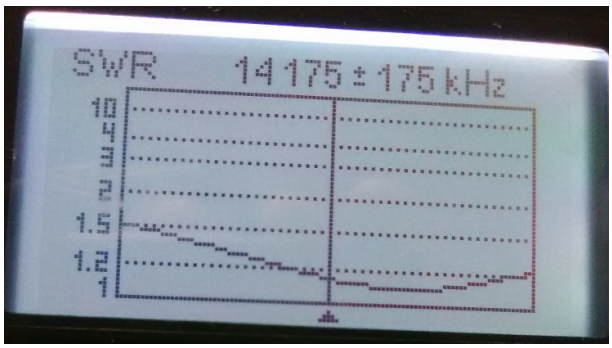
What have you been pondering?

Why a *tuned* HF antenna needs a tuner

I've heard a fair number of amateurs say that one should cut a wire HF antenna to the proper dimensions for resonance, instead of purchasing an unnecessary tuner. After all, they say, that's the purpose of a ***tuner***, right?

I'm confining this discussion to antennas intended for transmission on 1.8 MHz through 30.0 MHz, which encompasses all of the HF bands, plus 160 meters. The reasons I'm not going to apply this to VHF or UHF are that 1) store-bought VHF / UHF antennas *tend* to exhibit very low SWR across the bands and 2) many are difficult to tune, while you can easily fashion a hardware match for the rest.

Let's say that I create a dipole for 20 meters, using all the math necessary to cut the elements to the right lengths. Then, once I construct it and examine it with an antenna analyzer, I'm very happy to see that the SWR bandwidth across the entire 20-meter band resembles a smile, like this:



It shows about 1.5 SWR at 14.000 and 1.2 SWR at 14.350, dipping to about 1.1 SWR at the lowest point, about 14.245 MHz. I'm not sure how it could look better! So, because the antenna appears so good on the analyzer, I'm never going to need a tuner with it. Or will I?

There are two good reasons for me to use a tuner with this antenna, in spite of its stellar-looking SWR: to reduce signal loss and to make better use of the signal that does arrive at the antenna.

One of the biggest reasons I want low SWR is to reduce the amount of signal lost in my coax with each trip through it. So, if I kept my transceiver right at 14.245 MHz, I'll minimizing the signal power lost in the coax. But that's just not reasonable, since I want to make use of the *entire* 20-meter band.

A tuner can help me do just that, and once I select a frequency, I can direct the tuner to match the antenna system at the new frequency, then my antenna system has achieved an optimal SWR once again, minimizing my signal loss through my coax.

Next, the point where the SWR shows the lowest across the band is called the *resonant frequency*, so-called because at that point the antenna system impedance is *resistive*. If I tune away from resonance, my antenna system impedance becomes *reactive* instead of resistive, capacitively reactive below, and inductively reactive above.

Power fed into a reactive load is neither consumed nor dissipated, and so is not transmitted, and is reflected back to the transceiver, and again some of it will be lost in the coax as heat. Adding my tuner to the antenna system will once again allow me to operate on a section of the 20-meter band that's above or below the original resonant frequency, making good use of the signal by sending it to a resistive, instead of reactive, load.

One more (important) reason to use a tuner is to increase your antenna's bandwidth. While the example I gave shows complete band coverage by my 20-meter antenna, if my antenna for some reason does not provide that coverage, a tuner can help compensate.

Noji Ratzlaff, KNØJI (kn0ji@arrl.net)

Hot Tips

Good info for the new ham, and old stuff to refresh your memory

Backup emergency power

When the lights go out, that often means they've been running on *commercial power*, which is the electricity that's provided by the utility company. It would be convenient, and in some cases life-saving, to have a way of restoring at least some of your appliances to normal function quickly following such an event. Let's examine a few ways to implement emergency power in case of an outage.

One of the first, if not most convenient sources of emergency or backup electrical power is ***battery***. If you're on your desktop radio when the power goes out, you can easily disconnect your radio from its power supply, plug in your backup battery, and you're back in business within a minute. Possessing that kind of convenience means you need to have a battery that's large enough to handle your power needs, and that's already charged and ready to be used at a moment's notice.

Generator

Another reliable but temporary power source is a ***generator***. It might be a little less convenient than a battery, but a generator can provide house current for several appliances, whereas a battery can only deliver direct current to one or two items. You can keep your generator going for as long as your fuel supply holds out. Be sure and keep your running generator outdoors, and not inside your garage or your house. If you do have a generator connected to your house, it's useful to have a transfer switch, which can re-route the source from commercial to generator in a single flip.

Solar

Yet another popular standby power source is ***solar***. As long as the Sun's out, even when it's cloudy, a solar panel can deliver seemingly free electrical power to your radio and other equipment. Because solar radiation is not constant, however, the panel voltage rises and falls, and needs to be regulated and stored for it to be useful to you as an emergency power source. Your solar setup will need both a ***charge controller*** and a ***battery*** to even out the flow of power delivery.

Some other unusual emergency power backup possibilities include ***wind turbine***, ***water wheel***, or even ***bicycle***. All of these require a small generator, but again because of their constantly changing voltages, you'll need to route their electrical power through a charge controller and a power converter, to prevent damaging the battery from over-charging.

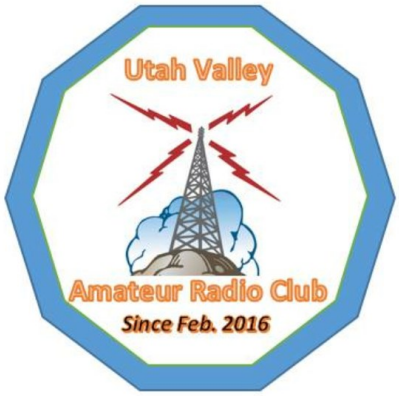
Failover

While you can most likely run across the room and retrieve a charged battery to restore your radio's power during an emergency, it might be a lot more convenient if it were already connected to your radio in some way. Many of these emergency electrical power solutions we've discussed can automatically switch over to the battery upon detecting that the city power has gone out. Others require a ***failover device***, one that immediately switches from commercial power to battery. This way, while you're on the radio, even transmitting, and the power goes out, you might never know you've switched to battery power.

The emergency power solutions we've been discussing involve what you can do once commercial power fails. But they can also be helpful when another power source quits or has drained. For example, when your HT battery has given its last breath, it's handy to carry a ***spare*** battery for your radio, just in case.

DIY

Worthwhile projects you can build on your own



Random-wire antenna

There might come a time when you'll find yourself with an HF transceiver, but in need of an antenna that's not readily available. In the early days of amateur radio, many operators discovered that they could easily build or acquire an AM transmitter and receiver, but could not afford a shiny, new beam. Instead, they often resorted to using an unknown length of wire left over from another project or from somebody's junk pile, and created a *random-wire antenna*.

A random-wire antenna is nothing more than an a wire of arbitrary length, but that's long enough to serve your HF needs. And because it connects to your station by one end (rather than somewhere in the middle) of the antenna, it's considered an *end-fed antenna*, complete with all the advantages (multiple bands) and disadvantages (shack RF generator and high impedance) that go with an end-fed type. But because its length is rather undetermined, it's not likely to be resonant on any amateur frequency.

In fact, if you have a choice, you should obtain the reasonably longest wire you can find. And if you intend to use it only for receiving, such as for both amateur and shortwave bands, the wire is pretty much all you'll need. But if you plan to also transmit on amateur bands using the wire, you'll need to use a wide-range (matches high SWR) ***antenna tuner***.

Many modern transceivers include a built-in tuner, but many internal ones will not match a random-length wire antenna sufficiently to bring its SWR into tunable range, usually making an external tuner necessary. If your engineering skills are adequate, you can create a *matching network* instead, but today's commercial or store-bought tuners tend to cover a greater bandwidth, making a purchase rather attractive for most of us mere mortals.

Let's see what it'll take to get a random-wire antenna up and running.

Parts list

~500 feet 14 AWG THHN stranded wire

Two dogbone insulators

One ½˝ ground rod

One 1 ft RG-8X coax PL-259

Heat shrink tubing

One LDG AT-100ProII auto-tuner

100 feet of paracord

One ground clamp

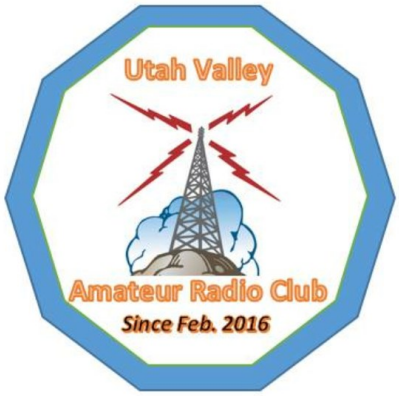
1 pkg crimp sleeves and a crimper

Construction

As mentioned, you should start with as long a wire as you can reasonably handle. You should also set aside an insulated counterpoise wire that's a quarter-wavelength of the lowest frequency you intend to use. A counterpoise is necessary for a random-wire antenna's performance, and to (help, but not completely) reduce the effects of common-mode current in your ham shack. For example, an 80-meter station should use a counterpoise wire that is

234 ÷ 3.6 MHz = 65 feet long.

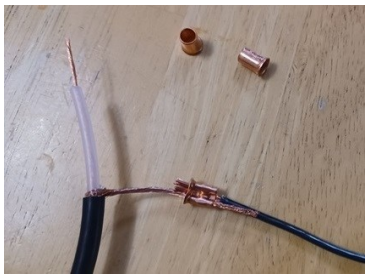
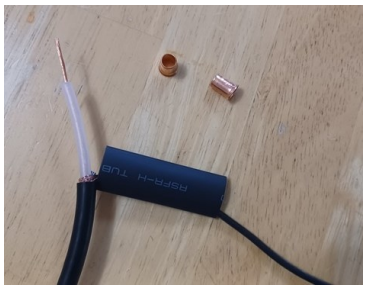
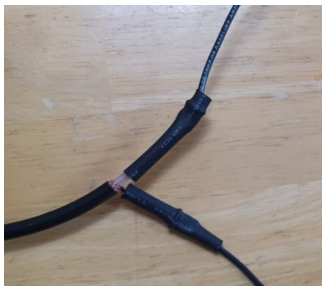
The value "234" is the conversion factor between a quarter-wavelength in MHz and feet, including the velocity factor of copper.



DIY, continued

Random-wire antenna

Cut the 1-foot coax in half and separate two inches of center conductor from the braid. Slip heat shrink tubing onto the counterpoise wire, crimp the counterpoise wire to the coax braid, and heat the tubing to insulate it from nearby conductors. Put a piece of masking tape around the counterpoise wire to differentiate it from the antenna wire.

Slip one end of the antenna wire through a dogbone insulator, then strip the same end of the antenna wire. Slip heat shrink tubing onto the antenna wire, crimp the antenna wire to the coax center conductor, slip the tubing over the crimped junction, and heat the tubing.

Insert the far end of the wire into a crimp sleeve, through one hole of a dogbone insulator, back through the same sleeve, and crimp the sleeve. Insert paracord through the other hole to tie the far end of the wire to a tree, fence, or other stable mounting point. Mount the antenna wire as high up as you can reasonably get it, the higher the better. If you don't have strong, independent supports, try draping the antenna wire over trees or anything else that'll get it high off the ground, again making sure the wire doesn't come near anything conductive.

Slip another piece of paracord through the empty hole of the dogbone insulator at the near end to tie it to something near your shack entry point. Leave enough slack in the antenna wire

DIY, continued

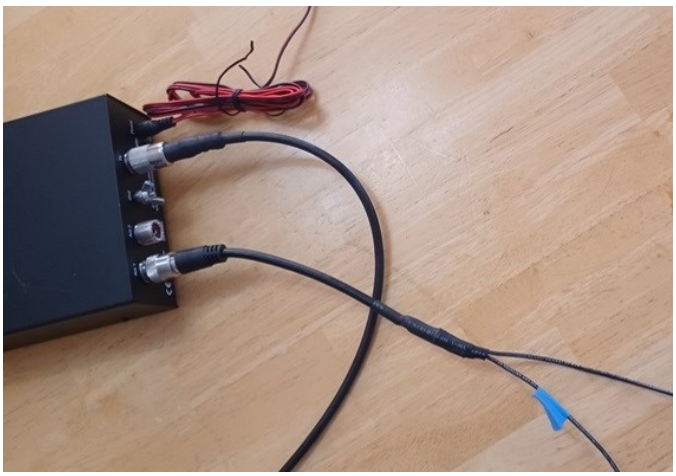
Random-wire antenna

to reach your tuner. Pinch the antenna wire around itself just outside the near-end dogbone insulator, and wrap one or two zip ties around it (just the wires) to form a strain relief. With the zip ties, form a loop large enough to allow free movement of the wires through it, but slightly smaller than the diameter of the dogbone insulator.

Installation and routing

Perhaps the most difficult task of installing a random-wire antenna is the routing of the antenna and counterpoise wires into your shack from the outside. We've covered some possibilities of doing just that with coax in a previous article, but we're dealing with a pair of plain, insulated wires in this case, which can be a little easier in a way, but come with some constraints because they're not shielded like coax is.

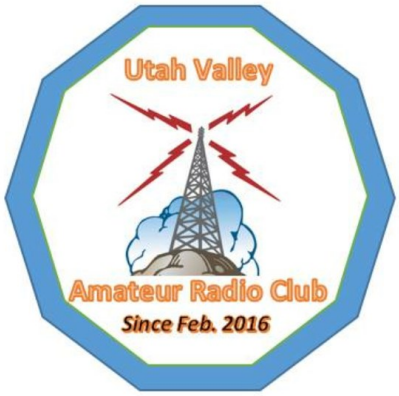
As much as possible, be sure to keep the antenna wire away from anything electrically conductive, such as gutters, aluminum siding, metal sheds, topsoil, metal window frames, and chain-linked fence. The wire will easily couple with metallic objects that are within a few inches of it, at the intended operating frequencies.



Lay the counterpoise wire on the ground and out from your shack. Drive all but six inches of the ground rod into the dirt a couple of feet closer to your shack than the end of the counterpoise wire. Attach the counterpoise wire to the ground rod using a ground clamp. Plug the PL-259 end of the 6-inch coax into the tuner "Antenna" connector. I selected the LDG AT-100Pro II tuner because of its wide tuning range (6 to 1000 ohms, or 20:1 SWR) for the price, but there are others that perform just as well for a reasonable price.

Long-wire antenna

By the way, some confuse the *long-wire antenna* with the random-wire antenna, and mistakenly use the terms interchangeably. While the difference between them might seem like semantics, a long-wire antenna is generally understood as one with a specified or pre-determined length, often a half-wavelength or quarter-wavelength multiple of the target band, while the



DIY, continued

Random-wire antenna

length of a random-wire antenna is generally regarded as unknown or unrelated to any multiple of known operating frequencies.

With all due respect to our truly "random" wire in this discussion, it turns out that some lengths of wire work better than others, in that they might be easier to tune. If you have the ability to actually measure the length of your antenna wire, the following long-wire antenna values (in feet) seem to work well for random-wire antennas, according to Jack Clarke VE3EED:

29	35.5	41	58	71	84	107	119	148	203	347	407	423

Advantages and disadvantages

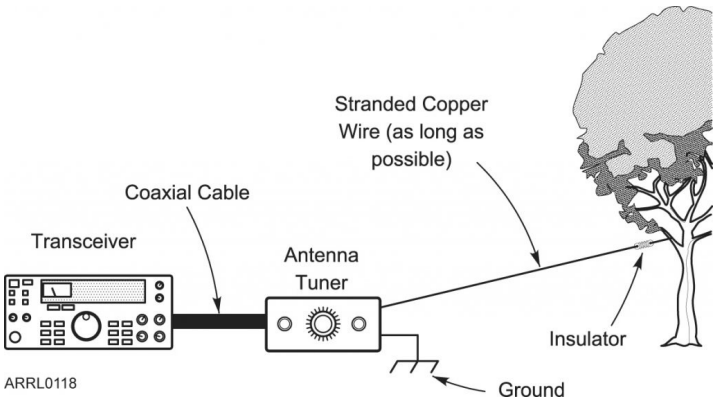
One drawback of the random-wire antenna you might encounter is the presence of *shack RF*, due to the fact that part of the antenna is inside your shack up to the tuner. While transmitting, this can cause your mic and rig enclosure to become too electrically active to touch ("hot"), your Wi-Fi router to lose internet connection, or a buzz to be transmitted with your signal. The ground connection on the tuner (directly connected in our case to the counterpoise wire) will help with some of this, but not all. You might need to install a common-mode choke between the tuner and the antenna to effectively reduce the amount of *noticeable* shack RF.

The good news is that we didn't need to make or buy a center insulator, purchase a feed line, or pull out the calculator to arrive at some engineering quantities. You might have wondered what kind of HF antenna you can install during an emergency, when you have nothing but wire. Even if you don't have one pre-made, like the one described in this discussion, you now have the knowledge to get something up. All you need is a rig, a good tuner, and some long, random-length wire. You can read an ARRL article on random-wire antennas here.

Summary

A random-wire antenna is nothing more than a length of wire used in an end-fed configuration, but it needs to be long enough to form an acceptable radiating element for HF frequencies. While simple in concept, actually constructing and installing one can get a little involved. It's not the same as a long-wire antenna, which is a wire antenna whose length is cut in relation to an actual fraction of a target frequency.

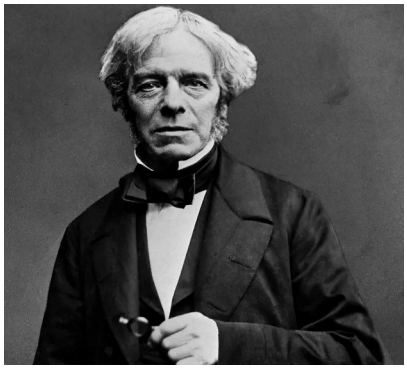
Noji Ratzlaff, KNØJI (kn0ji@arrl.net)



Living in the Past

Historical perspective

The student becomes the master



Having grown up near South London in relative poverty, Michael Faraday had very little formal education. At age 14, he became apprenticed to a local bookkeeper, and began studying many of the books he was asked to bind, gradually educating himself with philosophy and science.

In 1812 at the age of 20, Michael's apprenticeship neared the end, and he started attending lectures by the eminent English chemist Humphry Davy, perhaps one of the most famous scientists in the world at the time. Eventually, Michael sent Davy a 300-page book based on notes he had taken during these lectures, and immediately Davy was impressed. The next year, when Professor Davy damaged his eyesight in an accident, he invited Michael to be employed as his lab assistant, which Michael eagerly accepted.

Subsequently, Professor Davy took Michael on an 18-month tour of Europe to assist him. During that time, Faraday was able to meet other scientists such as Andre-Marie Ampere in Paris and Alessandro Volta In Milan. Once back in London, the Royal Institution increased Michael's salary, and Professor Davy began acknowledging him in his academic papers. By age 24, Michael had given his first lecture and published his first academic paper on matter, and at age 32, the Royal Society began to recognize Faraday as a notable scientist in his own right.

In 1831, Michael began a series of experiments on electromagnetism, in an attempt to take the discoveries of Hans Christian Oersted further. His breakthrough came when he wrapped two insulated coils of wire around an iron ring, and found that, upon passing a current through one coil, a momentary current was induced in the other coil, creating the first transformer through a phenomenon known as *mutual inductance*.

He also found that he could cause a current to flow in a wire when he moved a magnet through a loop of that wire, or moved the loop over a stationary magnet. These formed the foundation for the first electrical generator. Faraday's demonstrations established that ***a changing magnetic field will produce an electric field***, a relationship that was modeled by James Clerk Maxwell as *Faraday's Law*, and became one of Maxwell's Equations. Faraday devised his *lines of flux*, to visually illustrate the behavior of the electromagnetic fields.

Among Faraday's other achievements, he invented the electric motor, the Bunsen burner, popularized terms such as *anode*, *cathode*, *electrode*, and *ion*, and established that magnetism can affect rays of light. Near the end of his career, Faraday proposed that electromagnetic forces extended into the empty space around the conductor (think antenna). This idea was rejected by his fellow scientists, and Faraday did not live to see the eventual scientific community acceptance of his proposition.

Physicist Ernest Rutherford later stated, *When we consider the magnitude and extent of his discoveries and their influence on the progress of science and of industry, there is no honour too great to pay to the memory of Faraday, one of the greatest scientific discoverers of all time.*

The SI derived unit for ***capacitance*** (the **Farad**, symbol "F") was named in Michael's honor. You can read more about his life and achievement history on the Famous Scientists website.

Side of Bacon

A little ham humor

THE RAILROAD TELEGRAPHER

NO. 19. PEORIA, ILL., DEC. 14, 1895. VOL. 12.

OFFICIAL ORGAN
Order of Railroad Telegraphers of North America.

J. R. T. AUSTON, Editor.

W. N. Gates, Advertising Agent. 29 Euclid Ave, Cleveland, Ohio.

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Subscription $1.00 per year. Published Weekly.

used by telegraphers and means an inefficient telegrapher; one who has very little ability to send or receive messages but who are eagerly sought after by some railroad superintendents of telegraph because they work cheap. Professors of telegraph colleges pay some of the superintendents a liberal fee for "curing" their hams, but some are so green that their presence in railroad offices causes trains to bump each other and passengers to wear wooden limbs and coffins. Newspaper dispatches tell the public such bumps were caused by an "error in train orders." If green railroad officials who are old enough to know better than to jeopardize public life and property by distributing green hams among the railroad stations. The only way this ham business can be regulated is by state legislation. Every railroad telegrapher should carry a certificate issued by a state board of examiners.

NEW CARDS READY.

Another fiscal year is drawing to a close and every member should secure a new card. The organization representative of railroad telegraphers to be a

EVOLUTION OF A HAM.

The uninitiated may think that this ham is one of "Armour's best," but it is not. In fact it is not a ham at all; merely a young man from the country who has paid his tuition fee to a so-called Telegraph College. "Ham" is a term hams were not being cured by avaricious railroad officials there would be fewer "errors in orders." The usual fee for curing hams is $5—but some first-class curers receive as high as $15. The largest ham factory is located in St. Louis, Mo., and is owned and operated by some complete success must be properly upheld financially. Each member is taxed a few dollars per year in order that the organization may have finances to pay its expenses. The railroad telegraphers of this country have reaped great financial benefit from the O. R. T. and

This page from the 14 December 1895 issue of The Railroad Telegrapher *displays possibly the oldest known usage of the word "ham" and its meaning*

For Your Insight

Information you could use

Club meeting format

Here's the usual agenda for club meetings, at the Orem City Council Chamber Room, 56 N State St:

Talk-in frequency on the club repeaters

6:30 pm : Eyeball QSO

socialize / put faces with call signs

radio programmers available to help you

6:45 pm : Call the meeting to order

meeting lineup (agenda)

announcements / calendar / new hams

7:00 pm : Discussion / presentation

7:45 pm : Door prizes

7:55 pm : Dismiss and disassemble

8:00 pm : *Club QSY* to a local eatery

Something you'd like to see at the meetings?

Thanks to Heath Stevenson for making our monthly meetings possible!

Monthly meeting help

We're grateful for the volunteers who help with various tasks that make our club night just that much more friendly and useful to everybody. Monthly, we need help with

programming radios (thanks, Loren / Ralph!)

taking photos or videos during the meeting (thanks, Joe!)

operating the talk-in radio

setting up tables and chairs (thanks, Heath!)

Lynx

Websites for your education and leisure

Ham Radio Equipment
Ham Radio Nets
Radio Programming
Net Training Topics
76ers Group and UVARC Group pages
New Ham Page

Send your input to ***uvarcshack@gmail.com***

Test your knowledge

General and Extra review (answers next page)

G4EØ4 : Why is it best NOT to draw the DC power for a 100 watt HF transceiver from a vehicle's auxiliary power socket?

A. The socket is not wired with an RF-shielded power cable
B. The socket's wiring may be inadequate for the current drawn by the transceiver
C. The DC polarity of the socket is reversed from the polarity of modern HF transceivers
D. Drawing more than 50 watts from this socket could cause the engine to overheat

E5DØ6 : In what direction is the magnetic field oriented about a conductor in relation to the direction of electron flow?

A. In the same direction as the current
B. In a direction opposite to the current
C. In all directions; omni-directional
D. In a circle around the conductor

Calendar

What's happening
(times are Mountain Time)

Provo Ham Exam Sessions

Provo Fire Station #2, 2737 N Canyon Rd

Sign up at HamStudy.org/sessions

Wed 18 Oct, 7:00 to 8:30 pm
Sat 21 Oct, 2:30 to 5:00 pm
Wed 15 Nov, 7:00 to 8:30 pm
Sat 18 Nov, 2:30 to 5:00 pm
Sat 16 Dec, 2:30 to 5:00 pm
Wed 20 Dec, 7:00 to 8:30 pm

*Email **uvhamtest@gmail.com** for info*

Provo One-day Technician Courses*

Third Saturday Monthly at 8:00 am

Provo Fire Station #2, 2737 N Canyon Rd

** September through April*

2024 Orem Ham Radio Courses

Sign up at psclass.orem.org

Technician : Jan 23, 30, Feb 6, 13
General : Mar 19, 26, Apr 2, 9
Extra : Jul 16, 23, 30, Aug 6, 13
Technician : Sep 17, 24, Oct 1, 8

Club Meeting Calendar (6:30 pm)

On YouTube Live, and Facebook Live

October 5	November 2
December 7*	January 4
February 1	March 7
April 4	May 2

† *Ham Radio Fair, Pheasant Brook Park*

* *At the Orem Friendship Center*

Regular Nets

UVARC Family Net, Sun 3:30 pm, 146.780
NE UC ERC Net, 1st Sun 9:00 pm, 147.540s
UVARC Ladies' Net, Tue 7 pm, 146.780
DMR Utah Net, Wed 6 pm, TG 3149, CC 1
Utah 76'ers, Wed 7 pm, 146.760
UVARC HF Net, Wed 9 pm, 28.345 / 7.220
UVARC New Ham Net, Thu 7 pm, 146.780
CERT Ham Net, 2nd, 4th Thu 8:pm, 146.780
Utah County 6-meter Net, Fri 8 pm, 50.140
Family History Net, Sat 8 pm, 146.780
See a larger list of nets at noji.com/nets

Upcoming Contests

California QSO Party
10 am Sat Oct 7 to 4 pm Sun Oct 8

State QSO Parties
Sat Oct 14 : NV, AZ, PA, SD

CQ Worldwide DX Contest, SSB
6 pm Fri Oct 27 to 6 pm Sun Oct 29

ARRL Sweepstakes Contest, SSB
2 pm Sat Nov 18 to 8 pm Sun Nov 19

See a larger list at contestcalendar.com

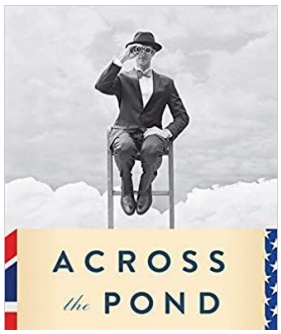
Answers to *Test your knowledge*

G4EØ4 : **B** (The socket's wiring may be inadequate for the current drawn by the transceiver)

E5DØ6 : **D** (In a circle around the conductor) [This is known as Oersted's Law]

Across the Pond

That is, the Utah Lake 'pond'



Eagle Mountain ham radio activities

This is a list of amateur radio activities that are organized near Eagle Mountain, primarily by Dave Becar KI6OSS. Unless otherwise noted, all these activities will be held at the Eagle Mountain City Hall, 1650 Stagecoach Run. Please contact Dave at **ki6oss6365@gmail.com** to register for any of the classes or exams, for any additional information, or questions in general.

October 2023 Technician Course

Thu 05 October, 7 to 9 pm
Wed 11 October, 7 to 9 pm
Thu 19 October, 7 to 9 pm
Thu 26 October, 7 to 9 pm
Thu 02 November, 7 to 9 pm

Ham Radio Exam Session

Sat 04 November, 10 am
Open to all, for any license class

Ham Radio Nets

Eagle Mountain ECT Net
Sundays, 9 pm 145.230- MHz (131.8 Hz)

Eagle Mountain Chimney Rock Stake
Sundays 8:30 pm 446.500 (s)

Eagle Mountain Central Stake
Saturday 8 pm 145.650 (s)

Vendors

For your convenience

Pockrus Joystick J-pole

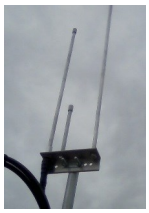
$30, open-stub aluminum half-wave, dual-band J-pole antenna

$40, 6-meter dipole, $20 for the 220 MHz (1.25 m) antenna

by Carl Pockrus, WE7OMG (email omgantennas@gmail.com to order)

Half-wave performance, solid construction, weather-proof, low wind-load

Probably the best-performing outdoor antenna you can get for the price



Super-Elastic Signal Stick

$20, vertical quarter-wave flexible antenna

by Richard Bateman, KD7BBC, of *SignalStuff* (and maker of *HamStudy*)

Super-performing antenna for your HT (handhold transceiver)

Visit SignalStuff and select SMA-Male, SMA-Female, or BNC

Ham Radio Podcasts v1.50

by Trevor Holyoak, AG7GX (email android@holyoak.com)

Stream podcasts (such as *100 Watts and a Wire*, *Amateur Radio Newsline*, *ARRL Audio News*, etc.) or download for later listening

For Android 4.1 and up (ad-free available for purchase)

Club Logo and Call Sign Embroidering

Want your call sign or name (or both!) embroidered on your shirt, your hoodie, your duffle? Or how about a club patch with your call sign?

by Glenna Gardner, WE7SEW (glenna0354@gmail.com or text 801-592-2503)

Call sign or name = $5, Both = $8, UVARC patch = $5, Patch with call = $9

Portable Aluminum J-pole

$60, sectioned, open-stub aluminum half-wave, dual-band J-pole antenna

by Stan, KJ7BDV and Kent, N7EKF (email skantenna@yahoo.com for info or call 801-372-7260)

Complete antenna breaks down into a compact 2″ x 6″ x 12″ package weighing only 3 lbs, perfect for backpacking and portable work where you really need a good 2-meter antenna

HamBadgers

Amateur radio name badges and other products

$10, official UVARC ham radio name badge with the club logo

Visit Ham Badgers and select Ham Radio Clubs > Utah Valley Amateur Radio Club

Email Eric Palmatier at hambadgers@gmail.com or call 919-249-8704

Where everybody knows your call sign

Utah Valley Amateur Radio Club
PO Box 1288
Orem, Utah, 84059-1288 USA

K7UVA
Phone/Text: 801-38-1865
Email: k7uva@arrl.net

Repeaters: 146.780–, 100.0
448.200–, 100.0 224.560–, 100.0
145.250-, 100.0 448.225-, 100.0
Newsletter input?
Email uvarcshack@gmail.com
Need help?
Email uvarcelmer@gmail.com

[See all our newsletters on uvarc.club]

We are the *Utah Valley Amateur Radio Club*, a 501(c)(3) non-profit (EIN 81-360-6416) Utah corporation that was organized in an obscure Orem fire station on 02-05-2016 to provide amateur radio enthusiasts in Utah County and surrounding areas a way to gather and discuss all things ham. Our primary purposes are to provide a local amateur radio resource, help new hams in their new-found adventures, and to give more experienced hams a reason to share their wealth of knowledge and wisdom in a friendly atmosphere of fellowship. We're an ARRL Affiliate and work in cooperation with the Utah VHF Society, but are not subsidiary to them, to ARRL, ARES, or any other organization, although many of our members and leaders might also belong to the same.

This newsletter is copyrighted and published by the Utah Valley Amateur Radio Club, and its purpose is to convey the tone and temperament of the club, to inform and entertain its members, and to entice the rest. To join, go to uvarc.club/join, then sign up at www.facebook.com/groups/uvarc/ to stay informed. For more information about our club or about amateur (ham) radio in general, please email or text or call us.

More than just a club, we invite you to become part of a great ham radio movement in Utah Valley

Our fearless leadership

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Vice President..... Chad Buttars
Secretary.....Caryn Alarcon
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Technology.....Trevor Holyoak

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Loren Chandler, WB1KE
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Harry English, AA1HE

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Heath Stevenson, KK7KOU
Orem City Emergency Manager

From all of us to you, 73